pleasure by reading these beautiful analyses of elementary but tantalizing paradoxes. Here also Bohr describes his principle of complementarity, which is his great tool for reconciling the apparent contradictions in quantum phenomona, and beyond that the basis for his whole philosophic position not only for science but more universally.

There is not enough space to discuss or even to mention the many wonderful papers in this volume or the rebuttals which Einstein gives to his critics in the last article. The careful reader will find this book an inexhaustible mine of insight and knowledge in the development of the scientific thought of our century.

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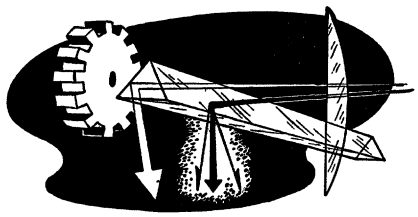

Reports on Progress in Physics. Vol. XII, 1948–49. London, S.W.1, England: The Physical Society, 1949. 382 pp. 2£ 2s. net.

This is the 12th volume of the admirable series of grouped surveys of topics in physics and the related sciences, which the Physical Society of London has been presenting to the world of physicists over a period of years. As contrasted with the nearest American approach to an equivalent—our *Reviews of Modern Physics*—the surveys of these volumes have often been better suited to the needs and powers of the nonspecialist, and many of them are actually readable. This volume is no exception to the rule; but since it is impossible to write 14 adequate reviews of as many articles on as many subjects, the reviewer can add little but names and titles to the foregoing words of general praise.

H. G. Thode and R. B. Shields deal with mass spectrometry, carefully defined as "instruments for ion collection and measurement in connection with relative-abundance determinations," and excluding the precise measurement of masses. B. V. Rollin treats briefly, under the title "Nuclear Paramagnetism," of what is more commonly called nuclear magnetic resonance. The essay of G. F. J. Garlick, "Phosphors and Phosphorescence," is "restricted to a survey of investigations of impurity-activated phosphors of crystalline structures which are synthesized by heat-treatment of their basic constituents." An article by D. K. C. MacDonald covers broadly and ably the field which he calls "spontaneous fluctuations," more commonly known perhaps as "noise." Transmutation, pair-production and other effects of the very short wave x-rays now available from accelerators are reviewed by W. Bosley and J. D. Craggs; and linear accelerators themselves by D. W. Fry and W. Walkinshaw of T. R. E., whose account will be read with especial interest by the constructors of high voltage research equipment in this country. G. O. Jones takes us abruptly to the other extreme of physics with a paper on "Viscosity and Related Properties in Glass," and N. Cabrera and N. F. Mott go clear over the border into chemistry with "Theory of the Oxidation of Metals."

We get back into solid-state physics in the second longest article of the book, that of E. Orowan, "Fracture and Strength of Solids," and then find ourselves among the gases and in the field of spectroscopy when we confront the "report" by A. Rubinowicz of which the purpose is "to summarize the more important of the recent advances in the field of atomic electromagnetic multipole radiation," and also the following essay by H. S. W. Massey, "Collisions between Atoms and Molecules at Ordinary Temperatures." K. Mendelssohn writes under the title "Low Temperature Physics," but confines himself to "recent advances in technique, superconductivity and superfluidity." M. Ross and J. S. Story provide us with a tabulation of slow neutron absorption cross-sections of the elements. Much the longest paper of the book is the last, the highly mathematical essay of J. de Boer entitled "Molecular Distribution and Equation of State of Gases." The reviewer envies anyone who can read all of these articles, good as they are.

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Fluorescence and Phosphorescence. Peter Pringsheim. New York-London: Interscience, 1949. 794 pp. $15.00.

An Introduction to Luminescence of Solids. Humboldt W. Leverenz. London: Chapman & Hall; New York: John Wiley, 1950. 569 pp. $12.00.

The science of luminescence is barely 100 years old (Sir George Stokes, 1852), but observations regarding luminescent materials are hundreds of years old. However, the understanding of the process of luminescence as contrasted to the emission of light due to temperature has been cleared up only within the last 30 years, after the successful interpretation of such observations on the basis of quantum theory. The first systematic attempt was Pringsheim's book, *Fluorescence and Phosphorescence in the Light of the New Atomic Theory,* 1921. This slender volume of about 200 pages, with some 260 references, is now expanded into the present imposing treatise containing a review of over 2,000 references (up to May, 1948).

In temperature radiation, the energy of radiation is due to the average energy content of the molecules as determined by temperature; whereas in the process of luminescence a molecule may receive an excitation energy exceeding the average temperature energy. This excitation energy is then emitted as luminescent radiation.

For luminescence it is therefore necessary that processes of excitation take place and that the energy taken up by atoms, molecules, or more complex systems be stored until it is emitted again as radiation. In rarefied gases, where the number of collisions is small, and in certain

organic and inorganic compounds containing a small number of active centers, these conditions are fulfilled.

Since gases, under proper excitation conditions, can always be made to luminesce, Pringsheim starts his discussion quite logically with the fluorescence of gases and vapors. After sketching the postulates of the quantum theory, energy levels and effects of perturbation are discussed. A brief discussion of the duration of luminescence processes leads to the definition of phosphorescence and fluorescence. Some time ago Pringsheim (following Perrin) pointed out that one has to define much more sharply the actual production of light which is due to transitions which may be determined (1), in fluorescence,

> . . . only by the inner (atomic, molecular, or also lattice dependent) transition probabilities, while (2) in phosphorescence there is always a metastable state involved in the mechanism, as a result of which the process of emission is essentially temperature dependent.

(Pringsheim, Faraday Society discussion, 1938).

Pringsheim deals first with monatomic gases and vapors, introducing the nomenclature and theory of spectra, discussing fluorescence lines and their various types of excitation, the absorption and emission process, and the interesting polarization phenomena of resonance radiation in a magnetic field. After a discussion of the perturbation of resonance radiation by collisions, the author treats sensitized fluorescence, which is of great importance in the understanding of the fundamental process of fluorescence. This chapter is followed by a discussion of fluorescence in diatomic and polyatomic gases and vapors. In all these cases the underlying basic theory is first introduced and then applied to the actual process of fluorescence in gases. In this way a solid theoretical foundation is laid for a logical understanding of the physical processes.

After these 280 pages devoted to gases, the fluorescence and phosphorescence of condensed systems are considered. A general survey of the nature of luminescent substances, the course of emission processes, and the yield is followed by a discussion of the polarization and angular intensity distribution of fluorescence radiation. There is a chapter on the fluorescence of organic compounds—a field recently made interesting by the discovery of the importance of these substances for scintillation counters. The luminescence of pure inorganic compounds is then studied and finally in some 150 pages crystal phosphors are dealt with.

Throughout the whole book by Pringsheim there is a good balance between the treatment of experimental results and their theoretical interpretation. Not since 1908, when Kayser summarized the empirical material of his time in the *Handbook of Spectroscopy* has such an encyclopedic task been attempted and successfully completed.

In a similar encyclopedic way the luminescence of solids has been treated by H. W. Leverenz, using well over 1,000 references dealing with this field of luminescence. Leverenz's book addresses itself to a somewhat different type of audience. It does not assume that many of the theoretical concepts of modern physics are known, and therefore the first 130 pages contain an introduction to some basic ideas of modern physics as applied to solid state problems. Elementary particles, kinetic theory, crystal symmetry, the difference between ideal and real crystals, and crystal growth are discussed. The section on the synthesis of luminescent solids, "phosphors," first introduces the concepts that are necessary to understand the problem from the point of view of analytical and physical chemistry. Then it outlines the synthesis and naming of phosphors and the possibility of designing a phosphor for a particular purpose. A table gives examples of initial ingredients, conditions of preparation, symbolism, and some properties of representative phosphors. This will be of great value to anybody who is interested in the preparation of these materials. There follows a discussion of energy states as applied to the problems of phosphors. The questions of energy transport and photoconduction, and the generalized energy level diagrams of phosphor centers are treated. After this preparation the luminescence of phosphors is covered in great detail.

Leverenz prefers the customary definition of fluorescence and phosphorescence, according to which phosphorescence is a long-time afterglow, whereas fluorescence stops at the end of the excitation. A discussion of the excitation process (with some useful figures on energy losses by radiation as well as by charged particles in passing through solid matter) leads to the questions of excitation spectra, energy transfer and storage, and treatment of electron traps and the trapping process in phosphors. This is followed by a discussion of emission spectra vs. temperature spectra, and finally by a discussion of emission spectra in a number of representative phosphors, both natural and synthetic.

In the phosphors themselves there is a correlation between the host crystal—or, as some investigators have called it, the basic lattice—and the phosphor properties as determined by the activators. The discussion dealing with these problems is perhaps the most important chapter because of the many problems still facing both the theorist and the experimenter.

The book closes with a chapter on the uses of phosphors. Leverenz describes applications of cathodoluminescence to cathode ray tubes in television, radar kinescopes, image tubes, and electron microscopes, as well as the use of ultraviolet-induced luminescence in fluorescent lamps, and the uses of x-ray luminescence.

In the end there is a brief reference to phosphors as particle and radiation detectors. The appendix contains some brief references to the preparation of certain pure phosphors, a summary of general spectral characteristics of luminescence, and a table giving a summary of some magnitudes and structures involved in the luminescence of solids. Besides a name and subject index there is a formula index for the most common phosphors. Leverenz has added a special representation of the periodic system which contains useful information usually omitted in other such representations.

Each book constitutes as nearly complete a summary of our knowledge of luminescence as might be given at

the present time. The rapid development in this field becomes clear if one considers the literature references and their growth in the time elapsed between the completion of the two manuscripts and their publication. For future editions we wish to point out that in works of such magnitude all references in the text to tables, figures, or formulas should always be accompanied by the page reference, or else the chapter number should be put at the top of each page; as it is, one has to spend a long time finding any reference.

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Atomic Age. (Sir Halley Stewart Lectures, 1948.) M. L. Oliphant *et al.* New York: Macmillan; London: Allen and Unwin, 1949. 149 pp. $2.50.

Atomic Energy Yearbook. John Tutin, Ed. New York: Prentice-Hall, 1949. 237 pp. $3.85.

Constructive Uses of Atomic Energy. S. C. Rothmann, Ed. New York: Harper, 1949. 258 pp. $3.00.

These recent additions to the current vogue for books about atomic energy are concerned with three different phases of the subject. The Sir Halley Stewart Lectures for 1948 are reproduced in *Atomic Age*. It presents the views of the authors on the military, economic, moral, and political aspects of atomic energy. Since each of the articles epitomizes the philosophy of a different specialist, the opinions and conclusions are divergent and stimulating. The chapter by P. M. S. Blackett is a concise presentation of his widely discussed evaluation of the military consequences of atomic bombing. This is followed by a protest against this assessment, ably presented by R. F. Harrod in the chapter on "Economic Consequences of Atomic Energy." Harrod also takes issue with optimistic predictions of the blessings of atomic power. He analyzes the various ways in which the new source of energy could influence world economy and concludes that he "is skeptical about the alleged economic benefits to humanity, anyhow in this generation."

Chapters by Bertrand Russell and Lionel Curtis deal with the moral and political necessity for some kind of world government. Although they are not in agreement on all phases, both present pithy and compelling arguments for an immediate if limited union of Western democracies. Their statements on the ultimate responsibilities of the United States in the atomic age, and the article "America as Atlas" by D. W. Brogan deserve serious consideration by all responsible American citizens.

In contrast to this book, which should be of interest to all readers, the other volumes will appeal to more limited interests. The *Atomic Energy Yearbook* is an excellent summary of current nonmilitary work in atomic energy. In it are listed the development and research establishments in all countries from which the information is obtainable. Detailed and factual accounts are presented of the kinds of work in progress at these various laboratories, the available facilities, the status of the programs, and probable trends for the immediate future. The book will be most valuable to workers who are interested in a broad survey of all activities in this field.

On the other hand, the articles in *Constructive Uses of Atomic Energy* are preponderantly speculative. The reader expecting detailed information or statements of actual accomplishments will be disappointed. The book consists of a collection of 14 short essays based on articles which originally appeared in a variety of technical and trade journals such as *Electronics, Iron Age, Machine Design, Chemical Engineering,* and *Occupational Medicine*. It is intended primarily for the casual reader who is interested in general predictions of the potential nonmilitary applications of atomic energy covering such subjects as atomic energy as a human asset, atomic energy in industry and the physical sciences, atomic power for industry and aircraft, radioactive isotopes for research, medical and industrial uses. Two of the appendices are very useful contributions; one is an excellent glossary of scientific terms used in most popular and scientific literature on atomic energy, the other is a valuable and extensive bibliography which will be of interest also to workers in the field.

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An Introduction to Molecular Spectra. Raynor C. Johnson. New York: Pitman Publ., 1949. 296 pp. $7.50.

This concise introductory text on molecular spectra provides, considering its brevity, a reasonably complete summary of the major features of molecular spectra. In its general level and approach it can, perhaps, serve as a companion volume to the well-known text by White on atomic spectra. It may thus occupy a place as yet unfilled by any generally accepted book on this subject. The nearest existing approximation to such a standard text is probably the first volume of the incomplete Herzberg trilogy, which treats only of diatomic molecules. The present book covers a wider field, necessarily less completely.

No knowledge of group theory or of quantum mechanics is assumed on the part of the student. This approach has, of course, both advantages and disadvantages, but seems a wise choice for a text treating so large a subject within so narrow a compass.

It will rightly be inferred, from what has been said, that the specialist will not find very much that is new or stimulating in the book. Except insofar as he is a teacher, the inference is correct. An idea of the condensation attained may be gotten from the titles and length of some of the 15 chapters. These include, for example, Electronic States of Molecules (16 pages), Rotational Terms and Vector Couplings (10 pages), Spectra of Polyatomic Molecules (53 pages). The Zeeman effect rates 17 pages; the Stark effect is not mentioned. The references are adequate, but barely so. The index is a mere three and one-half pages.

The student completing the text will have had a good once-over-lightly introduction to the subject; the text is solid enough but there is much that is not included. Whether one calls this omission of unnecessary detail or lack of thoroughness depends on the viewpoint; this reviewer, considering the probable use of the text, leans